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Mihalache et al.

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(54) **ASSESSING MOBILE USER AUTHENTICITY BASED ON COMMUNICATION ACTIVITY**

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H04M 1/68 (2006.01)
H04M 3/16 (2006.01)
H04W 12/06 (2009.01)

(52) **U.S. Cl.**
CPC *H04W 12/06* (2013.01)

(58) **Field of Classification Search**
CPC H04M 2215/32; H04M 15/00; H04M 2215/2026; H04M 17/00; H04W 4/24
USPC 455/405, 410
See application file for complete search history.

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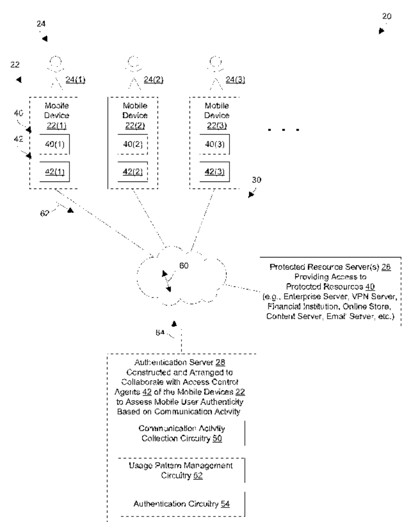
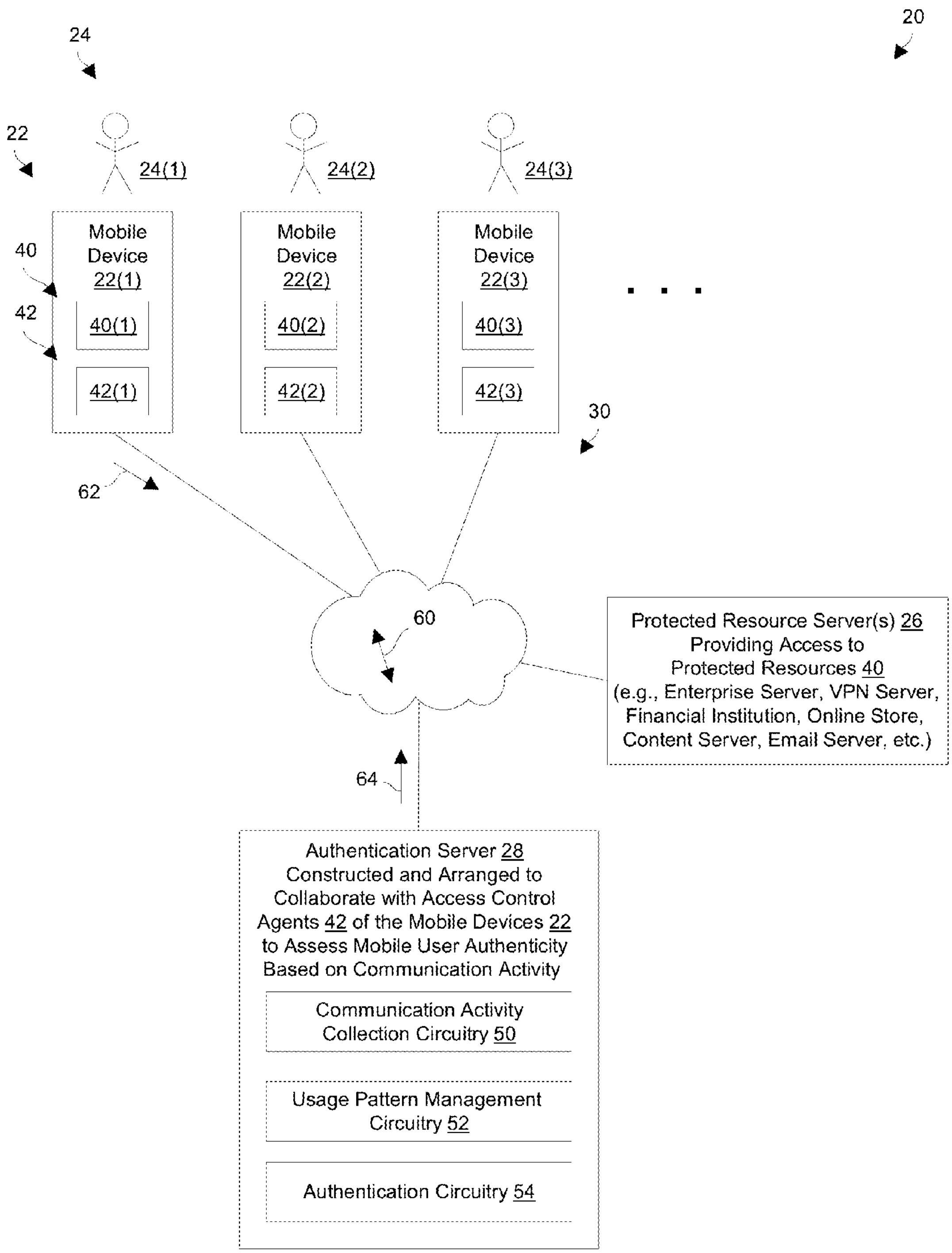
(57) **ABSTRACT**

A technique performs user authentication. The technique involves generating a first usage pattern from a first set of mobile device communications performed during a first period of time. The technique further involves generating a second usage pattern from a second set of mobile device communications performed during a second period of time. The technique further involves performing a comparison between the first and second usage patterns to determine whether a human provider of the first usage pattern and a human provider of the second usage pattern are the same person. Accordingly, a malicious person who steals a mobile device or operates a mock mobile device would nevertheless be identified as different from the legitimate user because the malicious person does not behave the same way as the legitimate user (e.g., does not have the same phone call behavior, does not have the same text messaging behavior, etc.).

18 Claims, 5 Drawing Sheets

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24
22
24(1)
24(2)
24(3)
Mobile Device 22(1)
Mobile Device 22(2)
Mobile Device 22(3)
40
42
40(1)
42(1)
40(2)
42(2)
40(3)
42(3)
. . .
30
62
60
Protected Resource Server(s) 26 Providing Access to Protected Resources 40 (e.g., Enterprise Server, VPN Server, Financial Institution, Online Store, Content Server, Email Server, etc.)
64
Authentication Server 28 Constructed and Arranged to Collaborate with Access Control Agents 42 of the Mobile Devices 22 to Assess Mobile User Authenticity Based on Communication Activity
Communication Activity Collection Circuitry 50
Usage Pattern Management Circuitry 52
Authentication Circuitry 54

FIG. 1

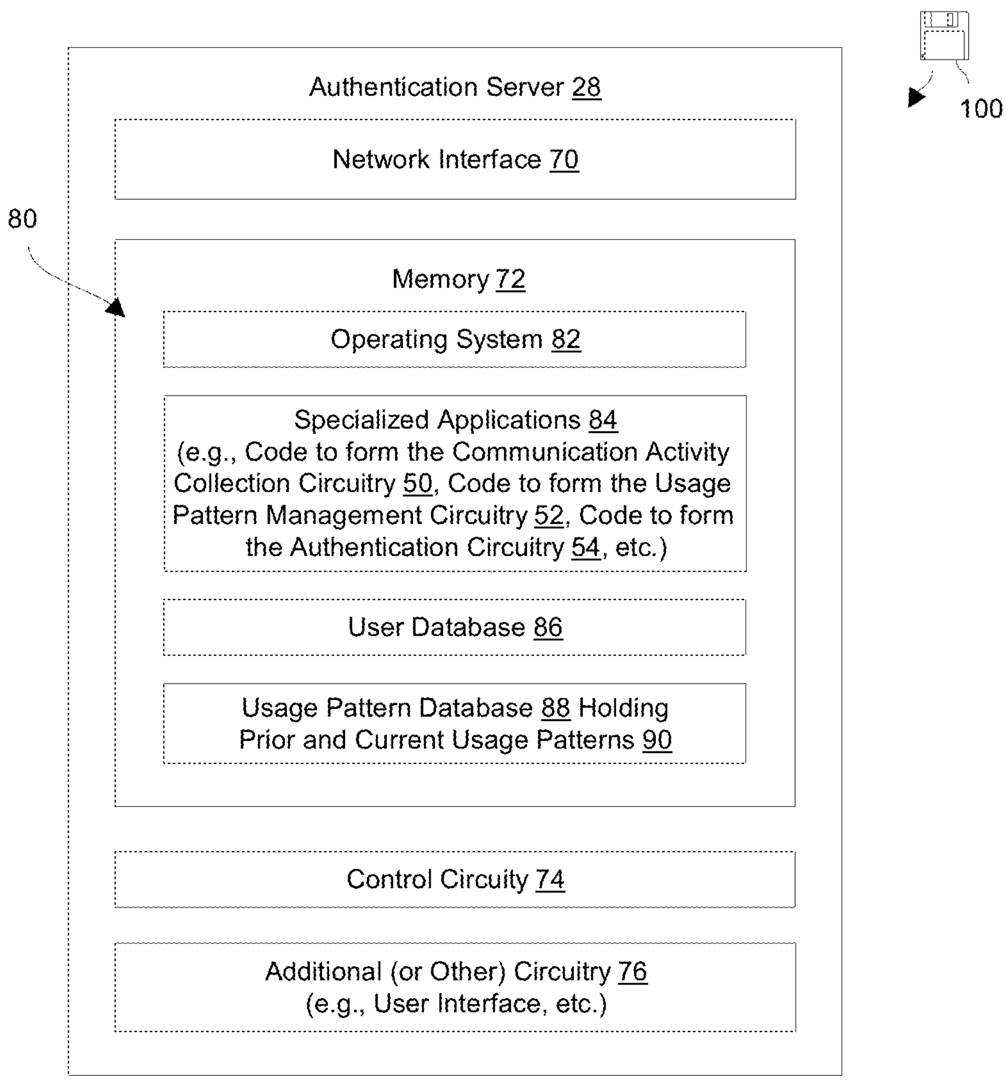
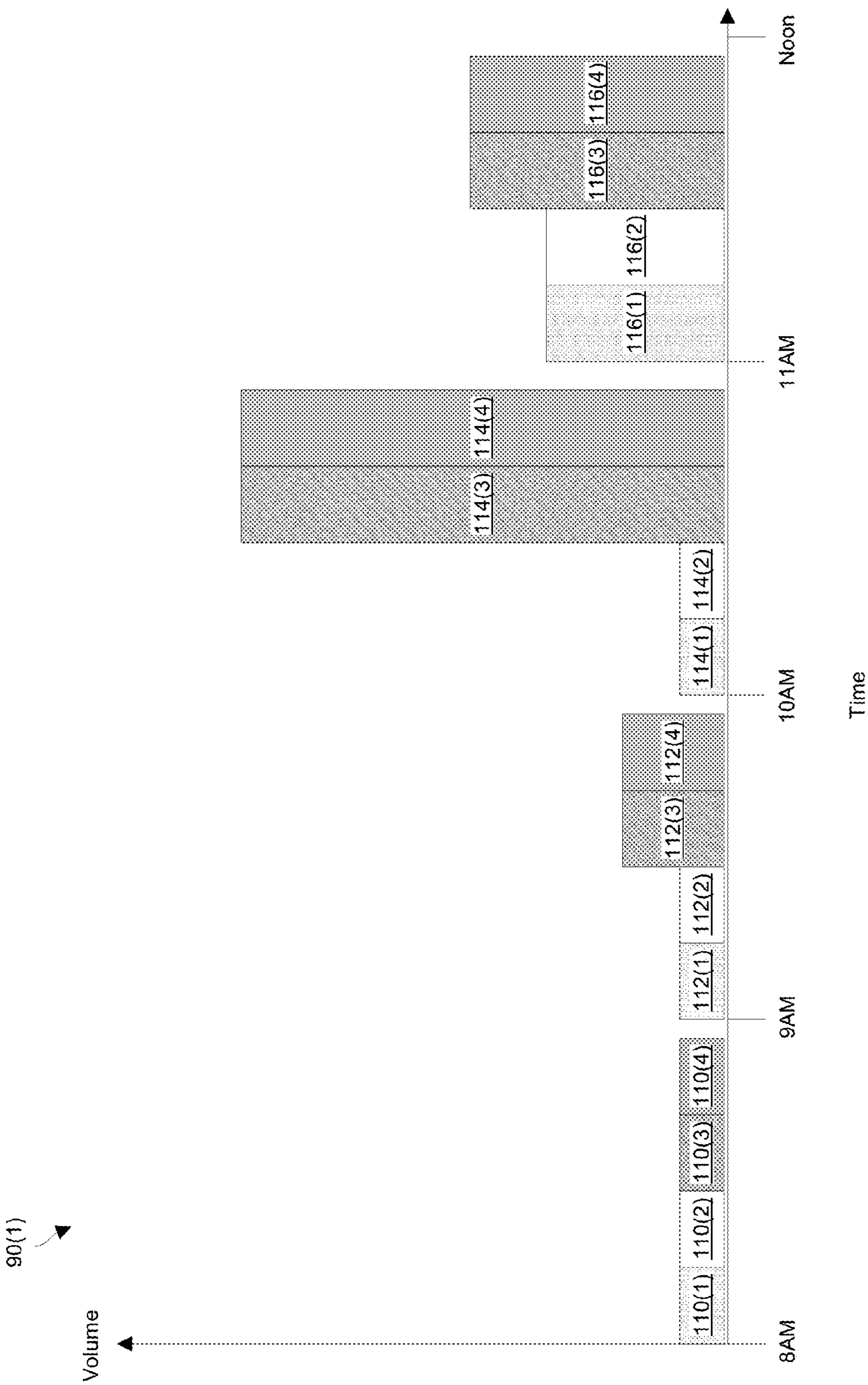

Authentication Server 28
Network Interface 70
80
Memory 72
Operating System 82
Specialized Applications 84 (e.g., Code to form the Communication Activity Collection Circuitry 50, Code to form the Usage Pattern Management Circuitry 52, Code to form the Authentication Circuitry 54, etc.)
User Database 86
Usage Pattern Database 88 Holding Prior and Current Usage Patterns 90
Control Circuitry 74
Additional (or Other) Circuitry 76 (e.g., User Interface, etc.)
100

FIG. 2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114(3)
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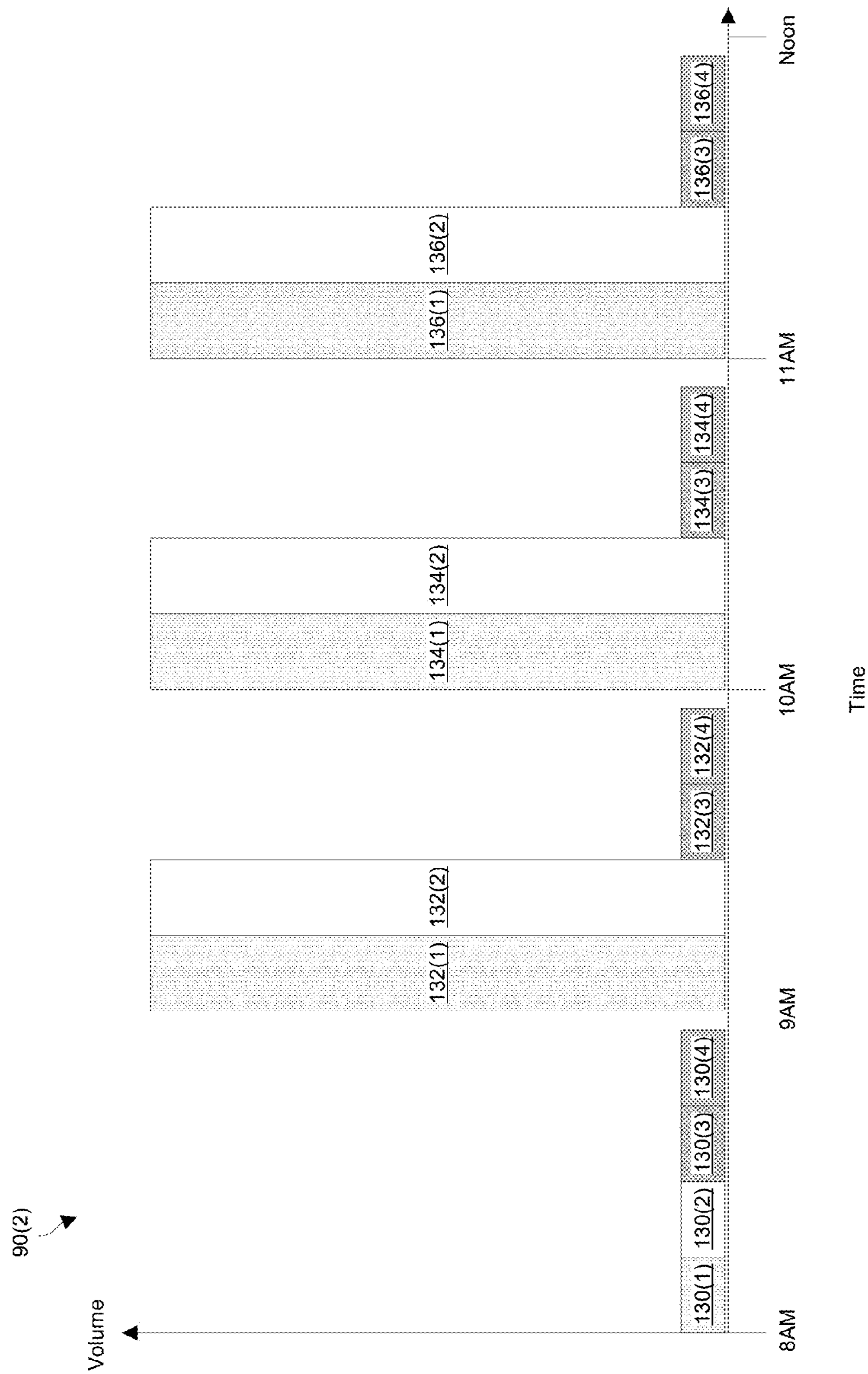
11AM
Noon
Time

FIG. 3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132(3)
132(4)
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134(2)
134(3)
134(4)
136(1)
136(2)
136(3)
136(4)

FIG. 4

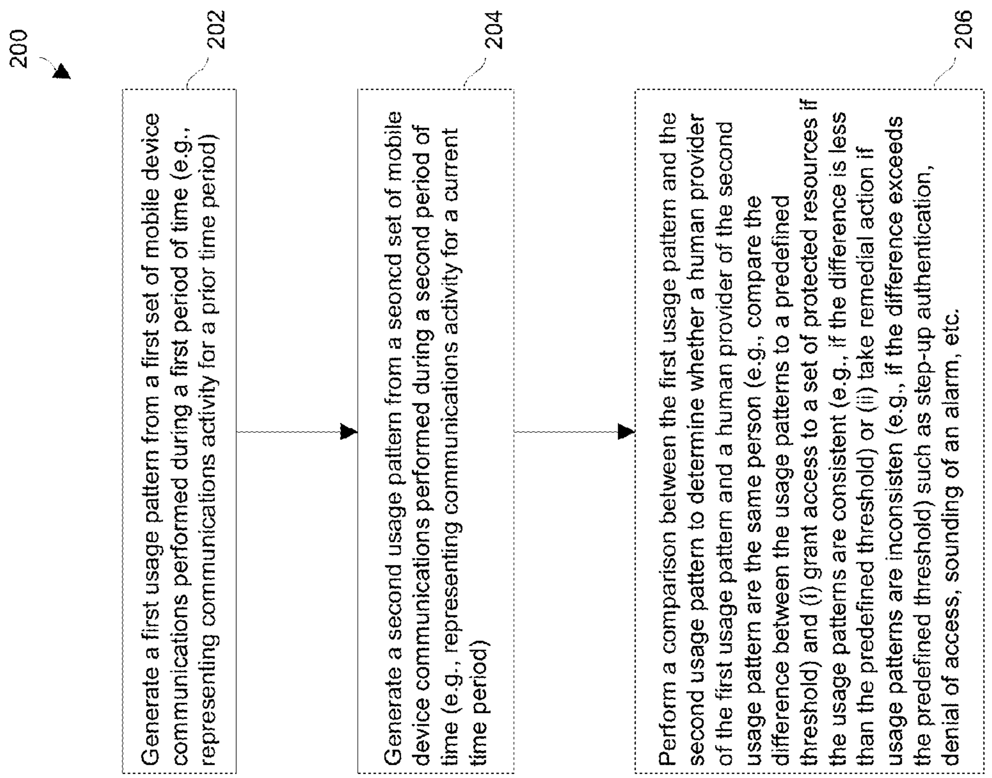
200
202
Generate a first usage pattern from a first set of mobile device communications performed during a first period of time (e.g., representing communications activity for a prior time period)
204
Generate a second usage pattern from a seoncd set of mobile device communications performed during a second period of time (e.g., representing communications activity for a current time period)
206
Perform a comparison between the first usage pattern and the second usage pattern to determine whether a human provider of the first usage pattern and a human provider of the second usage pattern are the same person (e.g., compare the difference between the usage patterns to a predefined threshold) and (i) grant access to a set of protected resources if the usage patterns are consistent (e.g., if the difference is less than the predefined threshold) or (ii) take remedial action if usage patterns are inconsisten (e.g., if the difference exceeds the predefined threshold) such as step-up authentication, denial of access, sounding of an alarm, etc.

FIG. 5

ASSESSING MOBILE USER AUTHENTICITY BASED ON COMMUNICATION ACTIVITY

BACKGROUND

Owners of smart phones can use their smart phones to access a variety of sensitive resources. Examples of such sensitive resources include the smart phones themselves, locally stored data, user accounts, virtual private networks (VPNs), online databases, remote content servers, and online games, to name a few.

Typically, to access a sensitive resource, the smart phone owner enters a personal identification number (PIN) or passcode into the smart phone. The entered PIN is then compared with an expected PIN to determine whether the owner is authentic. If the entered PIN is the same as the expected PIN, the smart phone owner is granted access to the sensitive resource.

SUMMARY

Unfortunately, there are deficiencies to the above-described conventional approach to controlling access to a sensitive resource. For example, a malicious person can steal the smart phone from the owner and, if the malicious person knows the owner's PIN, access the sensitive resource using the stolen smart phone. Additionally, a malicious person can configure another device to impersonate the owner's smart phone (e.g., copy the device name, use the owner's username and PIN, duplicate device cookies, etc.) and access the sensitive resource using the mock smart phone.

In contrast to the above-described conventional approach to controlling access to a sensitive resource, improved techniques are directed to assessing mobile user authenticity based on communication activity. In particular, a current usage pattern (e.g., communications activity during a current day) can be compared with a prior usage pattern (e.g., communications activity during a previous day) to determine whether a human provider of the current usage pattern and a human provider of the prior usage pattern are the same person. Such communications activity may include phone calls, mobile texting, and the like. Accordingly, if a malicious person steals the user's smart phone or creates an impersonating smart phone for malicious purposes, the malicious person would fail the assessment by not providing a usage pattern which is comparable to that of the authentic user. Along these lines, since it is unlikely that the malicious person would provide the same phone call behavior or the same text messaging behavior (e.g., the malicious person would not call into the office or text family), the malicious person will be identified as unauthentic and denied access. Such assessment can be performed continuously in the background as a transparent operation to the user.

One embodiment is directed to a method of performing user authentication. The method includes generating, by processing circuitry, a first usage pattern from a first set of mobile device communications performed during a first period of time. The method further includes generating, by the processing circuitry, a second usage pattern from a second set of mobile device communications performed during a second period of time. The method further includes performing, by the processing circuitry, a comparison between the first usage pattern and the second usage pattern to determine whether a human provider of the first usage pattern and a human provider of the second usage pattern are the same person. Accordingly, a malicious person who steals a mobile device or operates a mock mobile device would

nevertheless be identified as different from the authentic user because the malicious person does not behave the same way as the authentic user (e.g., does not make the same type of phone calls, does not send the same type of text messages, etc.).

In some arrangements, the first usage pattern identifies prior mobile device communication activity during a prior time period, and the second usage pattern identifies current mobile device communication activity during a current time period. In these arrangements, performing the comparison between the first and second usage patterns includes providing an authentication result indicating whether the current mobile device communication activity during the current time period matches the prior mobile device communication activity during the prior time period.

In some arrangements, providing the authentication result includes deriving a numerical score based on the comparison between the first and second usage patterns. The numerical score indicates how closely the current mobile device communication activity during the current time period matches the prior mobile device communication activity during the prior time period.

In some arrangements, providing the authentication result further includes outputting, as the authentication result, (i) a successful authentication value indicating successful user authentication when the numerical score is below a predefined threshold and (ii) an unsuccessful authentication value indicating unsuccessful user authentication when the numerical score is above the predefined threshold.

In some arrangements, generating the first usage pattern includes collecting mobile device communications data during the prior time period, and generating the second usage pattern includes collecting mobile device communications data during the current time period. In these arrangements, the prior time period and the current time period can cover a same length of time (e.g., a 15 minute interval, an hour, a four hour time window, a half day, a day, a week, etc.).

In some arrangements, collecting the mobile device communications data during the prior time period includes gathering the mobile device communications data during a first day, and collecting the mobile device communications data during the current time period includes gathering the mobile device communications data during a second day. In these arrangements, the first day and the second day are a same day of the week (e.g., both are Sundays, both are Mondays, etc.).

In some arrangements, generating the first usage pattern includes collecting mobile device communications data during the prior time period, and generating the second usage pattern includes collecting mobile device communications data during the current time period. In these arrangements, the prior time period is at least twice as long as the current time period (e.g., the prior time period covers four weeks while the current time period covers one week, the prior time period covers the last four Tuesdays while the current time period is the current Tuesday, etc.).

In some arrangements, collecting the mobile device communications data during the prior time period includes (i) gathering the mobile device communications data during a particular day of the week over multiple prior weeks and (ii) averaging the gathered mobile device communications data (e.g., the average communications activity for each Sunday during the last three weeks). In these arrangements, collecting the mobile device communications data during the current time period includes gathering the mobile device communications data during the particular day of the week on a current week (e.g., Sunday of the current week). Other lengths of time are suitable for use as well.

In some arrangements, the processing circuitry resides in an authentication server. In these arrangements, providing the authentication result includes transmitting the authentication result from the authentication server to a mobile device configured to operate based on the authentication result. Accordingly, the authentication server can provide remote access control on the mobile device (e.g., lock out the user of the mobile device).

In some arrangements, the processing circuitry resides in a mobile device. In these arrangements, providing the authentication result includes transmitting the authentication result from the mobile device to an authentication server. Accordingly, the mobile device can inform the authentication server of a failed authentication event.

In some arrangements, the authentication result indicates that authentication is unsuccessful. In these arrangements, the method may further include performing a remedial operation in response to the authentication result. Examples of remedial operations include directing a mobile device to perform a step-up authentication operation in which the mobile device directly challenges a user to successfully authenticate, locking out a user from a protected resource until the user successfully authenticates, sending an alarm message to a human administrator to indicate that authentication is unsuccessful, and removing access to one or more protected resources but not other protected resources, among others.

In some arrangements, performing a remedial operation includes providing the user with a step-up authentication challenge in a follow-up attempt to authenticate the user. In these arrangements performing the remedial operation further includes, in response to unsuccessful authentication via the step-up authentication challenge, (i) locking out the user from a protected resource which is otherwise accessible via a mobile device, and (ii) outputting an alarm to warn a human administrator that authentication of the user is unsuccessful.

It should be understood that, in the cloud context, certain electronic circuitry is formed by remote computer resources distributed over a network (e.g., circuitry of an authentication server). Such a computing environment is capable of providing certain advantages such as enhanced fault tolerance, load balancing, processing flexibility, etc.

Other embodiments are directed to electronic systems and apparatus, processing circuits, computer program products, and so on. Some embodiments are directed to various methods, electronic components and circuitry which are involved in performing user authentication.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages will be apparent from the following description of particular embodiments of the present disclosure, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of various embodiments of the present disclosure.

FIG. **1** is a block diagram of an electronic environment which is suitable for assessing mobile user authenticity based on communication activity.

FIG. **2** is a block diagram of an electronic apparatus of the electronic environment of FIG. **1**.

FIG. **3** is a block diagram of a first usage pattern which is generated based on communications activity from a human provider.

FIG. **4** is a block diagram of a second usage pattern which is generated based on communications activity from a human provider.

FIG. **5** is a flowchart of a procedure which is performed by the electronic apparatus of FIG. **2**.

DETAILED DESCRIPTION

An improved technique is directed to assessing mobile user authenticity based on communication activity. The results of such assessment can be used to control access to a set of protected resources. Along these lines, a current mobile device usage pattern (e.g., communications activity during a current day) can be compared with a prior mobile device usage pattern (e.g., communications activity during a previous day) to determine whether a human provider of the current usage pattern and a human provider of the prior usage pattern are the same person. Such communications activity can include phone calls, mobile texting, and other communications made from a mobile device. Accordingly, if a malicious person steals the user's mobile device or creates an impersonating mobile device to carry out malicious activities, the malicious person would fail authentication by not providing a usage pattern that is comparable to that of the authentic user. As a result, the malicious person can be denied access to the set of protected resources. Such assessment can be performed continuously in the background and thus be unobtrusive to the user.

It should be understood that assessments of mobile user authenticity based on communication activity can be performed completely locally within individual mobile devices, or involve a remote authentication server. Both situations are intended to belong to various embodiments of the invention. However, for illustration purposes and with reference to FIG. **1**, an embodiment in which assessment is performed by a dedicated authentication server will now be provided.

FIG. **1** shows an electronic environment **20** which is suitable for assessing mobile user authenticity based on communication activity. The electronic environment **20** includes mobile devices **22(1)**, **22(2)**, **22(3)**, . . . (collectively, mobile devices **22**) in possession of their respective users **24(1)**, **24(2)**, **24(3)**, . . . (collectively, users **24**), a set of protected resource servers **26** (i.e., one or more protected resource servers **26**), an authentication server **28**, and a communications medium **30**.

Each mobile device **22** includes a local set of resources **40** and an access control agent **42** (e.g., processing circuitry running specialized access control agent code). That is, the mobile device **22(1)** includes a local set of resources **40(1)** and an access control agent **42(1)**, the mobile device **22(2)** includes a local set of resources **40(2)** and an access control agent **42(2)**, and so on. The access control agent **42** of each mobile device **22** is constructed and arranged to provide controlled access to one or more protected resources **40** on behalf of its respective user **24**. Such protected resources **40** may reside locally on the mobile device **22** (e.g., see protected resources **40(1)**, **40(2)**, **40(3)**, . . .), or remotely on one or more protected resource servers **26**. Examples of suitable local protected resources **40** include user interface access (i.e., unlocking the mobile devices **22**), app access, contact list access, access to stored content, access to particular local features such as a camera, a phone, and so on.

The set of protected resource servers **26** maintains other protected resources **40**. Such protected resources **40** are capable of being accessed remotely by the mobile devices **22**. Examples of suitable remote protected resources **40** include (among others) accounts and databases of enterprises, VPNs/gateways/other networks, account access and transaction access with banks/brokerages/other financial institutions, transaction access at online stores, databases containing movies/music/files/other content, access to email, access to online games, and so on.

The authentication server **28** is equipped to perform initial or front-end authentication operations as well as secondary or back-end authentication operations. Such authentication can be used to control access to the protected resources **40**. As shown in FIG. **1** and as will be described in further detail shortly, the authentication server **28** includes communication activity collection circuitry **50** to collect the communication activity data from the mobile devices **22**, usage pattern management circuitry **52** to generate usage patterns based on the communication activity data, and authentication circuitry **54** to authenticate the users **24** where at least some authentication operations are base on comparisons between usage patterns.

The communications medium **30** is constructed and arranged to connect the various components of the electronic environment **20** together to enable these components to exchange electronic signals **60** (e.g., see the double arrow **60**). At least a portion of the communications medium **30** is illustrated as a cloud to indicate that the communications medium **30** is capable of having a variety of different topologies including backbone, hub-and-spoke, loop, irregular, combinations thereof, and so on. Along these lines, the communications medium **30** may include copper-based data communications devices and cabling, fiber optic devices and cabling, wireless devices, combinations thereof, etc. Furthermore, the communications medium **30** is capable of supporting LAN-based communications, SAN-based communications, cellular communications, combinations thereof, etc.

During operation, the users **24** operate their respective mobile devices **22** to perform useful work. Such work may include accessing one or more protected resources **40** (e.g., viewing a file, reading email, performing a banking transaction, etc.). Such operation may involve access to local protected resources **40** of the mobile devices **22** (e.g., access to certain apps, access to unlock the mobile devices, access to locally stored data, etc.). Alternatively or in combination, such operation may involve access to remote protected resources **40** of the external protected resource servers **26** (e.g., remote login access, remote access to content, ability to complete remote transactions, etc.). Other access control activities include installing apps, adding contacts, connecting to different networks, accessing resources, and so on. Some mobile devices **22** may be equipped with special peripherals that enable the users **24** to perform additional operations upon successful authentication such as make cellular calls, navigate using maps and GPS circuitry, take pictures, and so on.

During the course of such operation, the mobile devices **22** and the authentication server **28** collaborate to control access to the protected resources **40**. Particular details of such access control will now be provided in the context of an example.

Suppose that the user **24(1)** operates the mobile device **22(1)** over a period of time such as several weeks. Along these lines, each time the user **24(1)** starts to use the mobile device **22(1)**, the user **24(1)** may proceed through an initial authentication process (e.g., successfully login or sign-on to the mobile device **22(1)** using a PIN or passcode). Such operation may involve simple local authentication where all operations are performed via the access control agent **42(1)** of the mobile device **22(1)**. Alternatively, such operation may involve the access control agent **42(1)** taking input from the user **24(1)** and communicating with the authentication server **28** to remotely authenticate the user **24(1)** based on that input.

Once the user **24(1)** has successfully completed front-end authentication, the user **24(1)** is able to perform useful work on the mobile device **22(1)** and such activity may involve accessing protected resources **40** via the mobile device **22(1)**. For instance, the user **24(1)** may call a particular phone number for a teleconference every Monday at 10 am. Additionally, the user **24(1)** may routinely call in to the office 5-6 times a day. Furthermore, the user **24(1)** may frequently send text messages to personal contacts during lunchtime each day, and so on.

As the user **24(1)** carries out such activity using the mobile device **22(1)**, the access control agent **42(1)** notifies the authentication server **28** of such communications. Such conveyance of communication activity information (see arrow **62** in FIG. **1**) can occur in an event driven manner (e.g., in response to each communication activity) or can be queued/buffered temporarily and conveyed periodically in an aggregated form (e.g., every 15 minutes, hourly, four times a day, etc.). As mentioned earlier, such notification can take place transparently in the background.

The communication activity collection circuitry **50** of the authentication server **28** collects the communication activity information from the mobile device **22(1)** on behalf of the users **24(1)**, and the usage pattern management circuitry **52** generates a current usage pattern based on the communication activity information. The authentication circuitry **54** then compares the current usage pattern of the user **24(1)** to a previous usage pattern of the user **24(1)** to determine whether the same person is currently using the mobile device **22(1)**.

If the authentication circuitry **54** determines that the current and previous usage patterns match (e.g., within a predefined threshold), authentication is considered successful and the authentication server **28** informs the access control agent **42(1)** and perhaps the protected resource servers **26** (see the arrow **64** in FIG. **1**). That is, the user from which the current usage pattern is based is considered the same authentic user from which the previous usage pattern is based (i.e., the user is genuine). As a result, the access control agent **42(1)** can continue to allow the user **24(1)** to access the protected resources **40**.

However, if the authentication circuitry **54** determines that the current and previous usage patterns do not match (e.g., within the predefined threshold), authentication is considered unsuccessful and the authentication server **28** informs the access control agent **42(1)** and perhaps the protected resource servers **26** (again, see the arrow **64** in FIG. **1**). That is, the user from which the current usage pattern is based is considered different than the user from which the previous usage pattern is based. Here, the access control agent **42(1)** and/or the protected resource servers **26** are able to deny the user **24(1)** further access to the protected resources **40**. In some arrangements, the access control agent **42(1)** and/or the protected resource servers **26** may challenge the user **24(1)** with a stronger form of authentication and only remove access to the protected resources **40** if the user **24(1)** cannot successfully authenticate using the stronger form of authentication.

The authentication server **28** performs similar operations on behalf of the other users **24(2)**, **24(3)**, . . . as well. Accordingly, the authentication server **28** is able to concurrently support assessment of mobile user authenticity based on communication activity for multiple users **24** and multiple mobile devices **22**.

At this point, one should appreciate that different user behaviors will generate different usage patterns. For example, a user **24** that manages a team of workers may have a first usage pattern which involves routinely calling the same workers of the team throughout each business day. However, another user **24** that is in sales may routinely call different phone numbers (i.e., different potential customers) during a set time each day. Alternatively, another user **24** that works four days a week may routinely make a large number of calls on a particular day of each week (e.g., Monday) and may make relatively few calls if any but perhaps send a large number of text messages on another day of each week (e.g., Wednesday). As yet another example, another user **24** may normally sleep during the day and work late at nights or on weekends and thus have communications activity that is commensurate with such behavior.

In turn, the authentication server **28** is able to determine whether the users **24** of the mobile devices **22** are authentic based on comparing current usage patterns to previous usage patterns. In particular, if the current and previous usage patterns for a particular user **24** (e.g., the user **24(1)**) do not match within a predefined tolerance, authentication of that user **24** is considered unsuccessful and the authentication server **28** performs a remedial operation. In some arrangements, the authentication server **28** sends, as the message **52**, a command to lock out the user **24** from one or more of the protected resources **40** so that the user **24** must re-authenticate or re-login to regain access. In some arrangements, the authentication server **28** sends a challenge using a different form of authentication (e.g., a request for a new one-time use passcode, knowledge-based authentication, adaptive authentication, multi-factor authentication, biometric authentication, etc.). In some arrangements, the authentication server **28** sends an alarm to an administrator, and so on.

It should be understood that the time periods for the usage patterns can be chosen to minimize false positives (e.g., unsuccessful authentication of an authentic user **24**). Additionally, the time periods can be chosen to provide effective identification of fraudulent activity. Further details will now be provided with reference to FIG. **2**.

FIG. **2** shows particular details of the authentication server **28** of the electronic environment **20**. The authentication server **28** includes a network interface **70**, memory **72**, control circuitry **74**, and additional (or other) circuitry **76**.

The network interface **70** is constructed and arranged to connect the authentication server **28** to the communications medium **30**. Accordingly, the network interface **70** enables the authentication server **28** to communicate with the other components of the electronic environment **20** (FIG. **1**). Such communications may be copper-based, fiber-optic-based, or wireless (i.e., IP-based, SAN-based, cellular, Bluetooth, combinations thereof, and so on).

The memory **72** is intended to represent both volatile storage (e.g., DRAM, SRAM, etc.) and non-volatile storage (e.g., flash memory, magnetic disk drives, etc.). The memory **72** stores a variety of software constructs **80** including an operating system **82** to manage the computerized resources of the authentication server **28**, specialized applications **84** to form the various circuitry **50**, **52**, **54** of the authentication server **28**, a user database **86** to hold user profile information regarding the users **24**, a usage pattern database **88** to hold prior and current usage patterns **90** of the users **24** for use in assessment of mobile user authenticity.

The control circuitry **74** is constructed and arranged to operate in accordance with the various software constructs **80** stored in the memory **72**. Such circuitry may be implemented in a variety of ways including via one or more processors (or cores) running specialized software, application specific ICs (ASICs), field programmable gate arrays (FPGAs) and associated programs, discrete components, analog circuits, other hardware circuitry, combinations thereof, and so on. In the context of one or more processors executing software, a computer program product **100** is capable of delivering all or portions of the software to the authentication server **28**. The computer program product **100** has a non-transitory (or non-volatile) computer readable medium which stores a set of instructions which controls one or more operations of the authentication server **28**. Examples of suitable computer readable storage media include tangible articles of manufacture and apparatus which store instructions in a non-volatile manner such as CD-ROM, flash memory, disk memory, tape memory, and the like.

The additional (or other) circuitry **76** is optional and represents additional hardware that can be utilized by the authentication server **28**. For example, the authentication server **28** can include a user interface (i.e., a console or terminal) enabling a human administrator to set up new users **24**, to deal with alarms or warning messages, to administer routine maintenance, and so on. As another example, a portion of the authentication server **28** may operate as a source for access control agent code (e.g., an app store, a central app repository, etc.) to distribute such code to mobile devices **22** during configuration/enrollment. Other components and circuitry are suitable for use as well.

During operation, the authentication server **28** runs in accordance with the specialized applications **84** to reliably and robustly control access to the protected resources **40** within the electronic environment **20**. In particular, the authentication server **28** enrolls users **24** and stores the enrollment data in the user database **86**. Additionally, the authentication server **28** collects communications activity information from each mobile device **22** while the users **24** perform useful work using their mobile devices **22**, generates usage patterns **90** for each user **24**, and assesses authenticity of each user **24** based on the usage patterns **90**. Furthermore, the authentication server **28** may be involved in other forms of authentication such as front-end authentication (e.g., use of standard multi-factor authentication, adaptive authentication, knowledge-based authentication, etc.) to initially authenticate each user **24**, to control access to specific resources **40** (e.g., access to resources **40** on the protected resource servers **26**), for step-up authentication, and so on.

In connection with the user database **86**, the user database **86** includes user profiles for the users **24** of the mobile devices **22**. Each user profile includes, among other things, a user identifier to uniquely identify the user **24**, a mobile device identifier to uniquely identify the user's mobile device **22**, and other descriptive information. In some arrangements, the mobile device **22** is provisioned with additional security features (e.g., is configured as an authentication token, is configured as a container of security keys or other secrets that are made available in response to successful authentication, etc.), and the user database **84** stores copies of this information.

In connection with the usage pattern database **88**, the usage pattern database **88** is capable of storing prior and current usage patterns **90** derived from the communication activity data received from the mobile devices **22**. Recall that activity data can be gathered from the mobile devices **22** in an event driven manner and/or periodically.

In some arrangements, a prior usage pattern **90** and a current usage pattern **90** are stored in the usage pattern database **88** for each mobile device **22**. Such an arrangement is capable of identifying a potentially stolen mobile device **22** or impersonating mobile device **22** when there is a significant difference in the prior and current usage patterns **90** for a particular mobile device **22**.

In some arrangements, a prior usage pattern **90** and a current usage pattern **90** are stored in the usage pattern database **88** for each user **24**. Such an arrangement is capable of identifying a potentially stolen mobile device **22** or impersonating user **24** when there is a significant difference in the prior and current usage patterns **90** for a particular user **24**.

Other database arrangements and combinations are suitable for use as well. Further details will now be provided with reference to FIGS. **3** and **4**.

FIGS. **3** and **4** show example usage patterns **90(1)**, **90(2)** (collectively, usage patterns **90**) which can be generated by the authentication server **28** (also see FIGS. **1** and **2**) based on particular communications activity received from the mobile devices **22**. FIG. **3** shows details of a first usage pattern **90(1)**. FIG. **4** shows details of a second usage pattern **90(2)**.

Each usage pattern **90(1)**, **90(2)** in FIGS. **3** and **4** is illustrated as a graph in which time increases along a horizontal axis (right to left), and volume (i.e., amounts of activity) increases along the vertical axis (bottom to top). Such illustration is for simplicity and by way of example only. It should be understood that the authentication server **28** may store the data for such usage patterns **90** in manner that is quite different (e.g., as data structures with well-defined parameters/fields/counters, etc.) than what is shown visually as graphs in FIGS. **3** and **4**.

Each usage pattern **90** covers a predefined time period (e.g., a 15 minute interval, an hour, a four hour time window, half a day, a day, a week, etc.). The duration and particular time for the period is customizable and can be based on optimizing authentication effectiveness (e g, minimizing false positives where authentic users **24** are required to re-authenticate, effective identification of malicious activity by fraudulent users **24**, a balance approach, etc.).

Such usage patterns **90** can be based on multiple days of communication data. For example, a prior usage pattern **90** can be the average volume for each Monday morning over the last four Monday mornings.

Alternatively, such usage patterns **90** can be based on a single day of communication data. For example, a current usage pattern **90** can be the exact communications volume for a current Monday morning.

By way of example, the usage patterns **90(1)**, **90(2)** of FIGS. **3** and **4** cover a common time period of a work day morning, i.e., four hours from 8 am to noon on a Monday. In particular, the usage pattern **90(1)** represents average communications activity for each Monday morning over the last four weeks (i.e., a prior usage pattern). Additionally, the usage pattern **90(2)** represents precise communications activity currently for Monday of the current week (i.e., a current usage pattern).

As shown in FIGS. **3** and **4**, each hour time window includes four metrics:

1. the number of non-work-related phone calls made during that hour (see metrics **110(1)**, **112(1)**, **114(1)**, **116(1)**, **130(1)**, **132(1)**, **134(1)**, **136(1)**)
2. the number of non-work-related text messages sent during that hour (see metrics **110(2)**, **112(2)**, **114(2)**, **116(2)**, **130(2)**, **132(2)**, **134(2)**, **136(2)**)
3. the number of work-related phone calls made during that hour (see metrics **110(3)**, **112(3)**, **114(3)**, **116(3)**, **130(3)**, **132(3)**, **134(3)**, **136(3)**), and
4. the number of work-related text messages sent during that hour (see metrics **110(4)**, **112(4)**, **114(4)**, **116(4)**, **130(4)**, **132(4)**, **134(4)**, **136(4)**).

In some arrangements, the access control agent **42** distinguishes work related and non-work related communications based on destination addresses (e.g., the phone numbers used when making the phone calls and text messages). Other time intervals, other metrics, and other numbers of metrics are suitable for use as well.

By way of example only, the prior usage pattern **90(1)** shows that overall there was low communications activity between Sam and 9 am on the last four Mondays on average. Additionally, the average number of non-work-related phone calls made between 9 am and 10 am (metric **112(1)**) and the average number of non-work-related text messages sent between 9 am and 10 am (metric **112(2)**) stayed low, while the average number of work-related phone calls made between 9 am and 10 am (metric **112(3)**) and the average number of work-related text messages sent between 9 am and 10 am (metric **112(4)** slightly increased. Furthermore, the average number of non-work-related phone calls made between 10 am and 11 am (metric **114(1)**) and the average number of non-work-related text messages sent between 10 am and 11 am (metric **114(2)**) stayed low, while the average number of work-related phone calls made between 10 am and 11 am (metric **114(3)**) and the average number of work-related text messages sent between 10 am and 11 am (metric **114(4)** were at significant levels, and so on.

If a current user **24** is the same person as the user **24** that provided the usage pattern **90(1)** (FIG. **3**), similar behavior is expected. However, suppose that the usage pattern **90(2)** of FIG. **4** is generated from communications activity from a user **24** of the same mobile device **22** (or alternatively a user **24** indicating that he/she is the same person by using the same username/ID but different mobile devices **22**). Between Sam and 9 am, the communications activity of the current usage pattern (i.e., usage pattern **90(2)**) matches the communications activity of the prior usage pattern (i.e., usage pattern **90(1)** in FIG. **3**). In contrast, between 9 am and 10 am, the current usage pattern **90(2)** does not match the prior usage pattern **90(1)** (see FIG. **4**). Rather, the number of non-work-related phone calls made and the number of non-work-related text messages sent during this hour in the current usage pattern **90(2)** is significantly higher than that of the prior usage pattern **90(1)**.

As mentioned earlier, the authentication circuitry **54** of the authentication server **28** can be configured to compare usage patterns **90** at different time intervals (e.g., at 15 minute intervals, at one hour intervals, at four hour intervals, etc.). Such operation can be directed via control parameters which are set by a human administrator, by initial default parameters, etc.

If the authentication circuitry **54** is directed to compare usage patterns **90** at one hour intervals, by way of example, the authentication circuitry **54** may find that the difference between the usage patterns **90** for the interval between the Sam-9 am does not exceed the predefined threshold. In such a situation, the authentication server **28** considers the users **24** to be the same person and continues to grant access.

On the other hand, if the usage pattern differences do exceed the predetermined threshold, the authentication circuitry **54** performs a remedial operation. For example, suppose that the difference between the usage patterns **90** for the interval between the 9 am-10 am does exceed the predefined threshold. In particular, there is a significant increase in the volume of non-work related call and text messages (e.g., based on tracking destination phone/texting numbers). When the authentication circuitry **54** determines that the usage pattern difference exceeds the predefined threshold, the authentication circuitry **54** takes remedial action (e.g., requests the user **24** to authenticate using a stronger form of authentication to confirm that the user is authentic, etc.). Accordingly, in response to detection that the usage patterns **90** are inconsistent, the authentication circuitry **54** imposes stronger security.

As shown in FIGS. **3** and **4**, there are different patterns in communication activity during the time intervals between 10 am-11 am and between 11 am-noon. Accordingly, it is possible that the authentication circuitry **54** will compare the usage pattern differences for these intervals to the predefined threshold and again conclude that the differences exceed the predefined threshold. As a result, the authentication circuitry **54** will perform a remedial operation (e.g., the same remedial operation, a higher security remedial operation, etc.) in each of these intervals to impose security over the protected resources **40**.

On the other hand, if the usage pattern differences do not exceed the predetermined threshold, the authentication server **28** considers the users **24** to be the same person and continues to grant access. However, if the difference exceeds the predetermined threshold, the authentication server **28** considers the users **24** to be different people and performs a remedial operation such as prompting the current user **24** to authenticate using a stronger form of authentication.

Likewise, the other subsequent time windows (i.e., the span from 10 am to 11 am in FIGS. **3** and **4**, and the span from 11 am to noon in FIGS. **3** and **4**) show different behaviors. Such usage pattern differences, if they exceed the predetermined threshold, would result in remedial operation by the authentication server **28**.

It should be understood that a variety of techniques can be applied to compute the difference between usage patterns **90**. In some arrangements, the volume difference in each category (e.g., non-work phone calls, work phone calls, non-work text messaging, work text messaging, etc.) is mathematically summed and compared to the predefined threshold. In another arrangement, the volume differences between categories are weighted differently (e.g., calls being weighted more heavily than text messages, activity during normal business hours weighted more heavily than activity during off hours, etc.). In other arrangements, the categories are different (e.g., sales calls vs. existing customer calls vs. office calls vs. personal calls, etc.). In other arrangements, various totals or subtotals are normalized prior to comparison, and so on.

It should be further understood that the collection of communication activity data, generation and comparison of usage patterns **90** based on that communication activity was described above as being performed by the authentication server **28**. In other embodiments, such processing is performed locally by each mobile device **22** to impose access control.

Moreover, the time intervals for the usage patterns can be longer or shorter than one-hour in the example above. For instance, the interval can be over two hour (e.g., a sliding window applied to the communication activity of FIGS. **3** and **4**). As another example, the interval can be over four hours (e.g., the whole amount of communications activity shown in FIGS. **3** and **4**), and so on. Further details will now be provided with reference to FIG. **5**.

FIG. **5** is a flowchart of a procedure **200** for performing user authentication which is performed by an electronic apparatus such as a mobile device **22** or an authentication server **28**. At **202**, the electronic apparatus generates a first usage pattern **90** from a first set of mobile device communications performed during a first period of time. For example, the first usage pattern **90** can represent prior communications activity for a prior time period, or average communications activity for a prior time period (also see FIG. **3**).

At **204**, the electronic apparatus generates a second usage pattern **90** from a second set of mobile device communications performed during a second period of time. For example, the second usage pattern **90** can represent current communications activity for a current time period (also see FIG. **4**).

At **206**, the electronic apparatus performs a comparison between the first usage pattern **90** and the second usage pattern **90** to determine whether a human provider of the first usage pattern **90** and a human provider of the second usage pattern **90** are the same person. In some arrangements, the electronic apparatus derives a numerical score based on the comparison between the first and second usage patterns **90**, the numerical score indicating how closely the current mobile device communication activity during the current time period matches the prior mobile device communication activity during the prior time period. The electronic apparatus then compares the numerical score (or a normalized numerical score) to a predefined threshold and outputs, as an authentication result, a value indicating whether the numerical score is lower or higher than the predefined threshold, i.e., whether the usage patterns **90** are consistent.

If the numerical score is lower than the predefined threshold, the authentication result indicates successful user authentication and the user **24** is allowed to continue accessing the protected resources **40** (also see FIG. **1**). However, if the numerical score is higher than the predefined threshold, the authentication result indicates unsuccessful user authentication and the user **24** and a remedial operation is performed (e.g., performing step-up authentication, notifying an administrator, combinations thereof, etc.).

It should be understood that, when the assessment is performed remotely by an authentication server **28**, the authentication server **28** can send a signal back to the mobile device **22** as well as to one or more protected resource servers **26**. Such operation enables the authentication server **28** to control access based on the assessment (e.g., continue to grant access to protected resources, deny access, perform re-authentication, etc.).

Additionally, when the assessment is performed locally by the mobile device **22**, the mobile device **22** can send a signal to the authentication server **28**. In turn, the authentication server **28** may, based on a set of policies, send a signal back to the mobile device **22** as well as to one or more protected resource servers **26** in order to impose access control. Accordingly, the authentication server **28** is able to control access based on the assessment (e.g., continue to grant access to protected resources, deny access, perform re-authentication, etc.).

As described above, improved techniques are directed to assessing mobile user authenticity based on communication activity. In particular, a current usage pattern **90** (e.g., communications activity during a current day) can be compared with a prior usage pattern **90** (e.g., communications activity during a previous day) to determine whether a human provider of the current usage pattern **90** and a human provider of the prior usage pattern **90** are the same person. Such communications activity may include phone calls, mobile texting, and the like. Accordingly, if a malicious person steals the user's smart phone or creates an impersonating smart phone for malicious purposes, the malicious person would fail the assessment by not providing a comparable usage pattern as the authentic user. For example, since it is unlikely that the malicious person can provide the same phone call behavior or the same text messaging behavior, the malicious person will be identified as unauthentic and denied access. Such assessment can be performed continuously in the background as a transparent operation to the user.

While various embodiments of the present disclosure have been particularly shown and described, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present disclosure as defined by the appended claims.

For example, it should be understood that various components of the electronic environment **20** such as one or more of the servers **26**, **28** are capable of being implemented in or "moved to" the cloud, i.e., to remote computer resources distributed over a network. Here, the various computer resources may be distributed tightly (e.g., a server farm in a single facility) or over relatively large distances (e.g., over a campus, in different cities, coast to coast, etc.). In these situations, the network connecting the resources is capable of having a variety of different topologies including backbone, hub-and-spoke, loop, irregular, combinations thereof, and so on. Additionally, the network may include copper-based data communications devices and cabling, fiber optic devices and cabling, wireless devices, combinations thereof, etc. Furthermore, the network is capable of supporting LAN-based communications, SAN-based communications, combinations thereof, and so on.

Additionally, it should be understood that the communications activity described above was initiated by the mobile devices **22**. Such improved techniques may factor in other communications activity as well such as communications which are initiated by other devices (e.g., calls made to the mobile devices **22**, text messages received by the mobile devices **22**, etc.).

Furthermore, it should be understood that the way or manner in which the access control agents **42** count communications activity can be modified or updated over time (e.g., by changing policies/rules/filtering mechanisms, etc.). In particular, the access control agents **42** can be configured to take into account who the user communicates with (e.g., track which different phone numbers the user communicates with and revise over time), by which means (e.g., by which devices **22**), by frequency, the length of activity collection time frames, and so on. Accordingly, effectiveness of discovering fraudulent activity and minimizing false positives can be advanced over time in this manner.

Moreover, it should be understood that the above-described mobile devices **22** were described above in some arrangements as smart phones. It should be understood that the mobile devices **22** may be types of other than smart phones (e.g., tablet devices, personal assistant devices, laptops, etc.). Moreover, communications activity may include phone calls, text messages, emails, downloads, and various other types of external communications. Such modifications and enhancements are intended to belong to various embodiments of the disclosure.

What is claimed is:

1. A method of performing user authentication, the method comprising:

generating, by processing circuitry, a first usage pattern from a first set of mobile device communications performed during a first period of time;

generating, by the processing circuitry, a second usage pattern from a second set of mobile device communications performed during a second period of time; and

performing, by the processing circuitry, a comparison between the first usage pattern and the second usage pattern to determine whether a human provider of the first usage pattern and a human provider of the second usage pattern are the same person;

wherein the first usage pattern identifies prior mobile device communication activity during a prior time period;

wherein the second usage pattern identifies current mobile device communication activity during a current time period;

wherein performing the comparison between the first and second usage patterns includes providing an authentication result indicating whether the current mobile device communication activity during the current time period matches the prior mobile device communication activity during the prior time period;

wherein generating the first usage pattern includes collecting mobile device communications data during the prior time period;

wherein generating the second usage pattern includes collecting mobile device communications data during the current time period; and

wherein the prior time period is at least twice as long as the current time period.

2. A method as in claim **1** wherein providing the authentication result includes:

deriving a numerical score based on the comparison between the first and second usage patterns, the numerical score indicating how closely the current mobile device communication activity during the current time period matches the prior mobile device communication activity during the prior time period.

3. A method as in claim **2** wherein providing the authentication result further includes:

outputting, as the authentication result, (i) a successful authentication value indicating successful user authentication when the numerical score is below a predefined threshold and (ii) an unsuccessful authentication value indicating unsuccessful user authentication when the numerical score is above the predefined threshold.

4. A method as in claim **1** wherein collecting the mobile device communications data during the prior time period includes gathering the mobile device communications data during a first day;

wherein collecting the mobile device communications data during the current time period includes gathering the mobile device communications data during a second day; and

wherein the first day and the second day are a same day of the week.

5. A method as in claim **1** wherein collecting the mobile device communications data during the prior time period includes (i) gathering the mobile device communications data during a particular day of the week over multiple prior weeks and (ii) averaging the gathered mobile device communications data; and wherein collecting the mobile device communications data during the current time period includes gathering the mobile device communications data during the particular day of the week on a current week.

6. A method as in claim **1** wherein the processing circuitry resides in an authentication server; and wherein providing the authentication result includes:

transmitting the authentication result from the authentication server to a mobile device configured to operate based on the authentication result.

7. A method as in claim **1** wherein the processing circuitry resides in a mobile device; and wherein providing the authentication result includes:

transmitting the authentication result from the mobile device to an authentication server.

8. A method as in claim **1** wherein the authentication result indicates that authentication is unsuccessful; and wherein the method further comprises:

performing a remedial operation in response to the authentication result.

9. A method as in claim **8** wherein performing the remedial operation in response to the authentication result includes:

directing a mobile device to perform a step-up authentication operation in which the mobile device directly challenges a user to successfully authenticate.

10. A method as in claim **8** wherein performing the remedial operation in response to the authentication result includes:

locking out a user from a protected resource until the user successfully authenticates.

11. A method as in claim **8** wherein performing the remedial operation in response to the authentication result includes:

sending an alarm message to a human administrator to indicate that authentication is unsuccessful.

12. A method as in claim **1** wherein the human provider of the first usage pattern obtained access to a protected resource during the first period of time;

wherein the second period of time occurs after the first period of time;

wherein the authentication result indicates that the human provider of the first usage pattern and the human provider of the second usage pattern are not the same person; and

wherein the method further comprises:

in response to the result of the comparison indicating that the human provider of the first usage pattern and the human provider of the second usage pattern are not the same person, denying the human provider of the second usage pattern access to the protected resource.

13. A method as in claim **12** wherein performing the comparison between the first usage pattern and the second usage pattern forms a first user authentication operation; and wherein the method further comprises:

in response to denying the human provider of the second usage pattern access to the protected resource, providing the human provider of the second usage pattern with an authentication challenge which provides a stronger form of user authentication than that provided by performing the comparison between the first usage pattern and the second usage pattern in an attempt to authenticate the human provider of the second usage pattern in a second authentication operation.

14. An electronic apparatus, comprising:

memory; and

control circuitry coupled to the memory, the memory storing instructions which, when carried out by the control circuitry, cause the control circuitry to:

generate a first usage pattern from a first set of mobile device communications performed during a first period of time,

generate a second usage pattern from a second set of mobile device communications performed during a second period of time, and perform a comparison between the first usage pattern and the second usage pattern to determine whether a human provider of the first usage pattern and a human provider of the second usage pattern are the same person;

wherein the first usage pattern identifies prior mobile device communication activity during a prior time period;

wherein the second usage pattern identifies current mobile device communication activity during a current time period;

wherein the control circuitry, when performing the comparison between the first and second usage patterns, is constructed and arranged to provide an authentication result indicating whether the current mobile device communication activity during the current time period matches the prior mobile device communication activity during the prior time period;

wherein the control circuitry, when generating the first usage pattern, is constructed and arranged to collect mobile device communications data during the prior time period;

wherein the control circuitry, when generating the second usage pattern, is constructed and arranged to collect mobile device communications data during the current time period; and

wherein the prior time period is at least twice as long as the current time period.

15. An electronic apparatus as in claim **14** wherein the control circuitry, when providing the authentication result, is constructed and arranged to:

derive a numerical score based on the comparison between the first and second usage patterns, the numerical score indicating how closely the current mobile device communication activity during the current time period matches the prior mobile device communication activity during the prior time period; and

output, as the authentication result, (i) a successful authentication value indicating successful user authentication when the numerical score is below a predefined threshold and (ii) an unsuccessful authentication value indicating unsuccessful user authentication when the numerical score is above the predefined threshold.

16. An electronic apparatus as in claim **15**

wherein the control circuitry, when collecting the mobile device communications data during the prior time period, is constructed and arranged to (i) gather the mobile device communications data during a particular day of the week over multiple prior weeks and (ii) average the gathered mobile device communications data; and

wherein the control circuitry, when collecting the mobile device communications data during the current time period, is constructed and arranged to gather the mobile device communications data during the particular day of the week on a current week.

17. An electronic apparatus as in claim **16** wherein the control circuitry is further constructed and arranged to perform a remedial operation by:

providing the user with a step-up authentication challenge in a follow-up attempt to authenticate the user, and

in response to unsuccessful authentication via the step-up authentication challenge, (i) lock out the user from a protected resource which is otherwise accessible via a mobile device, and (ii) output an alarm to warn a human administrator that authentication of the user is unsuccessful.

18. A computer program product having a non-transitory computer readable medium which stores a set of instructions to perform user authentication, the set of instructions, when carried out by computerized circuitry, causing the computerized circuitry to perform a method of:

generating a first usage pattern from a first set of mobile device communications performed during a first period of time;

generating a second usage pattern from a second set of mobile device communications performed during a second period of time; and

performing a comparison between the first usage pattern and the second usage pattern to determine whether a human provider of the first usage pattern and a human provider of the second usage pattern are the same person;

wherein the first usage pattern identifies prior mobile device communication activity during a prior time period;

wherein the second usage pattern identifies current mobile device communication activity during a current time period;

wherein performing the comparison between the first and second usage patterns includes providing an authentication result indicating whether the current mobile device communication activity during the current time period matches the prior mobile device communication activity during the prior time period;

wherein generating the first usage pattern includes collecting mobile device communications data during the prior time period;

wherein generating the second usage pattern includes collecting mobile device communications data during the current time period; and

wherein the prior time period is at least twice as long as the current time period.

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